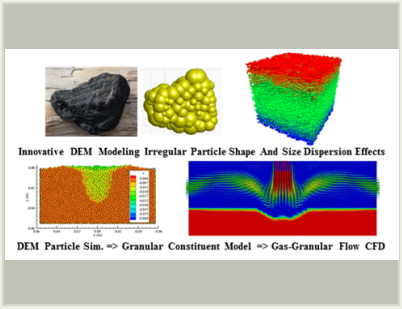
Particle Flow Physics Modeling for Extreme Environments, Phase II

Completed Technology Project (2014 - 2019)

Project Introduction

The liberation of particles induced by rocket plume flow from spacecraft landing on unprepared regolith of the Moon, Mars, and other destinations poses high mission risks for robotic and human exploration activities. This process occurs in a combination of "extreme environments" that combine low gravity, little or no atmosphere, rocket exhaust gas flow that is supersonic and partially rarefied, and unusual geological and mechanical properties of highly irregular surface regolith. CFDRC and the University of Florida will deliver unique plume driven erosion simulation software for such environments by combining novel granular physics simulation modules developed by UF with multi-phase gas-granular flow simulation software developed by CFDRC. Granular flow constitutive models, formulated through first-principle 3-D Discrete Element Method particle kinetics and implemented in an efficient Eulerian gas-granular flow solver are the foundation of this software. The fidelity of these simulations will be advanced towards simulating particle compositions with broad shape and size variations. Novel particle kinetics modeling concepts will be applied to formulate granular flow physics models for both, realistic irregular particle shapes and dispersed particle size distributions. Phase I demonstrated the successful implementation and validation of irregular granular shape physics modeling in CFDRC's gas-granular multi-phase flow solver. An approach for extension to poly-disperse particle mixture simulations was also developed. Full integration of these models in Phase II will enable the simulation of gas flow interaction with poly-disperse, irregular shaped particle materials. Extensive verification, validation, and application demonstrations will be performed. The proposed technology development will result in unprecedented computer modeling capability for predicting liberation and flow of realistic granular material compositions in extreme extra-terrestrial environments.



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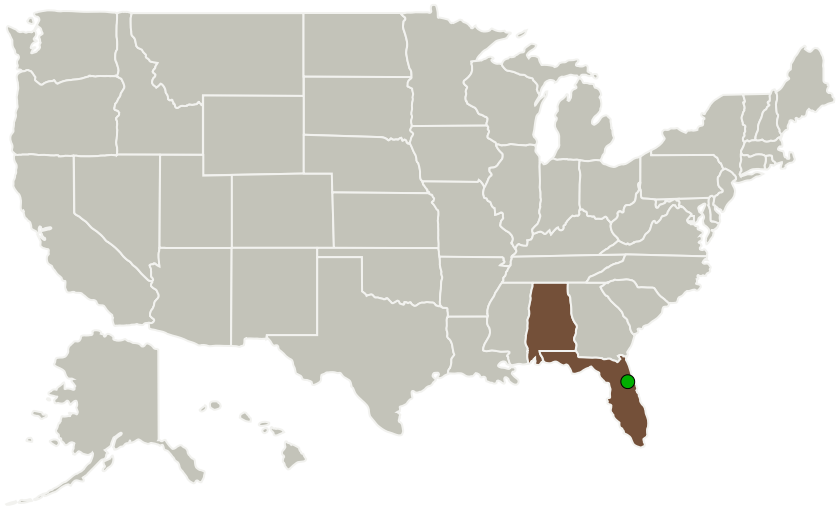
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
CFD Research Corporation	Lead Organization	Industry	Huntsville, Alabama
Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida
University of Florida	Supporting Organization	Academia	Gainesville, Florida

Primary U.S. Work Locations	
Alabama	Florida

Project Transitions

September 2014: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

CFD Research Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Peter Liever

Co-Investigator:

Peter Liever

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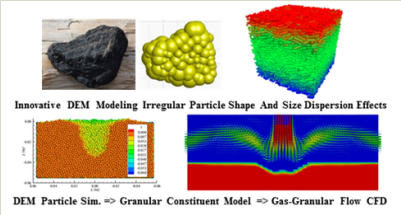
April 2019: Closed out

Closeout Summary: Particle Flow Physics Modeling for Extreme Environments, Phase II Project Image

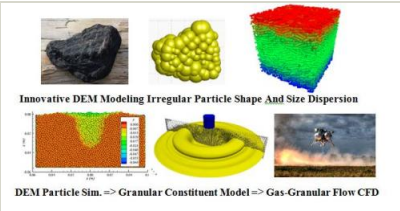
Closeout Documentation:

- Final Summary Chart Image*(https://techport.nasa.gov/file/137540)*

Images



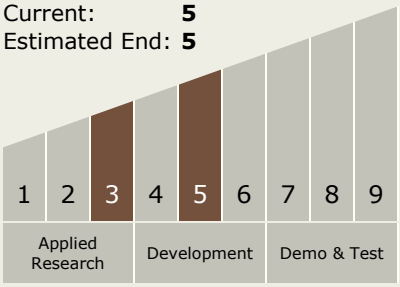
Briefing Chart Image
Particle Flow Physics Modeling for Extreme Environments, Phase II *(https://techport.nasa.gov/image/133963)*



Final Summary Chart Image
Particle Flow Physics Modeling for Extreme Environments, Phase II Project Image *(https://techport.nasa.gov/image/126453)*

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - TX09.4 Vehicle Systems
    - TX09.4.5 Modeling and Simulation for EDL

Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System